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TRAINING IN INCIDENT COMMAND

Incident Commanders at airports today face much more than just responding to aircraft fires; they face a multitude of disasters, ranging from hijackings to hazardous material incidents, acts of terrorism that can involve weapons of mass destruction, natural catastrophes such as earthquakes, floods, hurricanes, and more. How does today's Incident Commander prepare for these types of disasters?

With IATA reporting that, in the near future, there will be a major passenger aircraft accident someplace in the world every 7-10 days, we cannot complacently accept that it will not happen in our backyards. Americans are equally complacent relative to the reality of the terrorist threat. Weapons of mass destruction are out there, and in mass quantities. Our airports, with the millions of people travelling through them daily, are prime targets for these terrorist groups, and face a very real element of threat today.

In an attempt to emphasize the magnitude of airport traffic, the following information is provided based on data compiled from various sources, including ACI World and the Civil Transport Association.

Using the top five busiest airports in North America, based on passengers per year, the figures for 1997 are [17]:

Chicago, IL	70,385,073
Atlanta, GA	68,205,769
Dallas/Ft. Worth	60,488,713
Los Angeles, CA	60,142,588
San Francisco, CA	40,493, 959

This represents over 300 million people traveling through these five airports alone.

Since 1990, the following incidents have been identified as accidents resulting in death or destruction of the aircraft by fire:

Date	Carrier	Place of Accident	Type of Aircraft	Occupants	Deaths
2/90	Philippines	Manila	B-737	119	8
5/90	Northwest	Detroit	DC-9	44	8
2/91	US Air	Los Angeles	B737	89	22
7/91	Nationair	Jeddah	DC-8	261	261
7/92	TWA	New York	L-1011	292	0
12/92	Martinair	Faro, Portugal	DC-10	340	56
7/94	US Air	Charlotte	DC-9-31	57	37
6/95	ValuJet	Atlanta	DC-9-32	62	0
5/96	ValuJet	Miami	DC-9	109	109
7/96	TWA	New York	B-747	230	230

Table 1 Civil Transport Accidents (1990-96) with Fire-Related Deaths or Destruction of the Aircraft by Fire [8]

The above chart reflects the frequency of events that involved fire and plane loss, and graphically identifies the need for an equal measure of prevention and preparedness for incidents occurring at airports, not only in the U.S., but around the world.

As a long-time resident of Orlando, I have taken the liberty of demonstrating the typical growth of North American airports by using Orlando International Airport's projected growth chart through the year 2014. By 2014, Orlando estimates that there will be 55 million passengers a year passing through OIA [2].

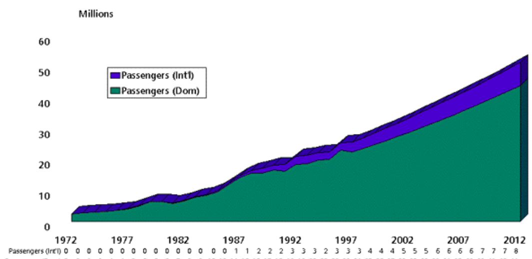

Figure 1-1 Orlando International Airport – projected growth [2]

With airlines and regulatory agencies making our airports and aircraft safer with each passing day, it makes little sense to not address the issues of preparedness in the same robust manner. Increased security and safer aircraft are but one phase of providing responsible and capable protection to our travelling public, by those responsible for protecting them. We must ensure that aircraft and airport safety is met on both the prevention and preparedness sides with equal vigor. As the old saying goes, "An ounce of prevention is better than a pound of cure...."

It is fortunate that these events rarely happen, but the expedient and efficient reaction of the command and control staff at the incident is critical to the saving of life and property. The Officer in Charge (OIC) does not (fortunately) have the opportunity to train on-the-job. How then does the command and control team train to meet the challenge of a 747 loaded with fuel, passengers, and cargo, with only minutes to mitigate the event before disaster? The impact of a 747 aircraft incident:

Cargo	300 tons
Fuel	12 large fuel tankers
Baggage	3 moving vans
Passengers	400 people
Crew	30 people
Ground Personnel?	
Ground Property?	
Hazardous Material Involvement?	

Current training methods do not provide sufficient evidence that they properly assess the capabilities of fire service officers in managing the command and control roles for which they have been assigned responsibility [3,4,6]. Mock-up exercises, live fire pits and fuselages, table top trainers, sand boxes and chalk boards do not provide an adequate level of stress to measure an OIC and his team's ability to perform in a high stress situational environment. Another means of training is needed to create this environment of stressful reality, recreating an event the magnitude of an actual situation perpetrated at an airport (either natural or one created by man).

The incident commander and his crew are much like that of a modern day battle field commander and his soldiers [5]. They have an enemy opposing them, be it fire, biological, hazardous materials, or enemy soldiers. Both commanders will use the same basic methods to combat the situation: Command, Control, & Communications. What does the incident commander do, and how does he do it?

The incident commander must gather information about the current situation confronting him/her, and needs as much information as possible, quickly and accurately, in order to issue a command or allocate resources to mitigate the incident in the most appropriate manner.

It has been recognized by research conducted over the past 20 years studying simulation training devices and training methodologies, that a student's ability to perform the cognitive and psycho-motor skills learned under low stress conditions crumbles when the level of stress is raised [3,4,14]. Knowing the individual will face real responsibility for his or her actions is an important factor that influences the way an individual will respond. Observable symptoms of a person faced with a high level of stress will often be that he is slow to react, displays an ability to deal with only one issue of the incident at a time, shows signs of unhealthy tension, and freezes in thought and action [4]. Statistics show that many who have demonstrated adequate standards of performance under simulated conditions, develop stress symptoms when conducting live training. Allowing those who are vulnerable to stress to be responsible to perform during a potentially lethal operation introduces an unacceptable risk to the safety of personnel and equipment. There is, therefore, a need to develop responsibility/stress training to provide personnel to operate these systems and manage these teams safely, and to demonstrate their ability to do so before taking up the role of incident commander at a major airport disaster. The disaster itself is not the time to train.

Further studies (NFA, Oklahoma Bombing, Cranfield, MOD)[14,15,16] illustrate that a student will relate to past experiences for similarities between a past emergency and the one they are currently faced with. He/she will select one or two past experiences, and will react with those same corrective actions. These and other studies have shown that an incident commander does not perform an analytical study to weigh one course of action against another. Armed with this information, the incident commander then moves towards a command step and begins to combat the situation.

Today's armies and navies have long had state-of-the-art simulators for training their commanders and crews in the techniques of command, control and communications. These devices provide a real-world, real-time training experience to perform training, practice, evaluation and test. Should those responsible for our lives and property at airports be provided with anything less?

With the advent of technology, a simulator capable of re-creating the proper levels of stress is needed at our airports today. Furthermore, to meet the ever challenging role that our airport incident commanders and their crews will need to train at, a method which will gradually build up their confidence and measure their readiness to assume the role and responsibility of dealing with a major airport incident is needed.

What are the responsibilities that must be measured in a high stress environment to recognize the readiness of an airport commander? In a study done by the Civil Aviation Authority in the United Kingdom (CAA Paper 98006)[4], the following competencies were identified:

- To quickly and calmly assess the incident situation and prioritize actions in order to ensure that maximum opportunities are afforded for the saving of lives.
- To deploy all available resources in an effective and efficient manner.
- To identify other resources required at the scene and request their attendance.
- To give required orders at the scene clearly and concisely.
- To delegate command roles and other responsibilities in the appropriate manner.

- To constantly monitor the situation for the duration of the incident and adapt the strategy to suit the changing circumstances.
- To ensure that the resources are being continually deployed in an effective and efficient manner and, where this is not the case, to order their redeployment.
- To ensure that appropriate safety procedures are enforced and monitored throughout the incident.
- To ensure that a calm, orderly and authoritative atmosphere is created and maintained throughout the incident.
- To ensure that other required resources are identified and requested within optimum time scales.
- To cooperate with senior officers from other key agencies on their arrival at the scene.

This study[4] further went on to say that investigations following major aircraft accidents in which loss of life has occurred reflected the inability of the incident commanders to effectively deal with the incident, and concluded that a more effective training device was required.

Essential to the development of an environment capable of delivering the high fidelity training suggested above, there is a need to understand how this training will be delivered and the processes involved.

The first step in identifying and implementing a high fidelity training program which will meet the standards, either mandated or recognized by industry as required or essential to meet, and deal with the magnitude of a major aircraft incident, is to conduct a training needs analysis. This process has been broken into several steps, and includes:

1. Review training needs & requirements.
2. Translate needs into required skills.
3. Determine cues and clues needed to teach identified skill sets.
4. Identify equipment necessary to deliver these cues and clues.
5. Develop a training method.
6. Develop a training plan.
7. Write a functional specification for each identified training device.
8. Integrate the training devices into the training plan.

The types of skills which are considered in the development of a simulation training device include perceptual, cognitive, procedural, and psychomotor:

1. Perceptual Skills - *Sensing of information*

Example: Judging wind velocity by observing the angle of flames and smoke

2. Cognitive Skills - *Decision making - logic*

Example: Choosing the type of agent to use on a particular type of fire

3. Procedural Skills - *Application of learned activities by rote*

Example: Standard operating procedures in fire fighting

4. Psychomotor Skills - *Physical dexterity-hand eye coordination*

Example: The ability to accurately target foam or other agent on to a fire

Once the skill sets are identified, there is then a need to determine the clues and cues needed to best teach the identified skill sets.

1. **Visual Cues/Clues** - Those skills which can be best developed though the use of sight.
Example: Identifying the type of fire by the color of the smoke.

2. **Sound Cues/Clues** - Those skills which can be best developed though the use of the sense of hearing.
Example: Recognition and understanding of radio communications.

3. **Physical Cues/Clues** - Those skills which can be best developed through the sense of touch.
Example: Recognition of fire behind closed doors through heat transfer via door or wall
.

Finally, the next step in providing an effective training device would be to develop a training plan.

1. Combine the skill sets required.
2. Identify the types of cues and clues needed for skill development.
3. Identify the specific training methods.
4. Develop the training plan.

Critical to the success of a simulation training device is the realism. Therefore, the

requirement to develop realistic appearing

Illustration 1-1 Environmental Conditions Impacting Sensory Perceptions

models within the software is essential. This can be accomplished by review of materials from various sources, allowing for the development of the key software elements. Following is a sample list of such elements related to an aircraft incident:

THE FIRE MODEL

A good deal of material is available from the National Institute of Standards and Technology and the Center for Fire Research with regard to fire spread and smoke transports models. This data contains analysis of particular fire and estimation tools based on hard formulation derived from physical laws and empirical data. ETC uses a realistic simulation of a fire model such that it can be used for effective command and control training. ETC selected the most important metrics of their zone fire models, and then approximated the peculiar nature of an aircraft fire. The result is a simpler model that will run in real time and will provide a good approximation of a fire.

The principle variable of concern is the rate of heat release. This value is in watts and is the best gauge of the size and strength of the fire. The rate of heat release varies with such things as time and the type of material. There are three stages in the life of a fire that should be modeled. These stages are growth, steady state, and decay. The model is based on a t-squared fire. A common technique in full scale simulation of a particular fire is to use what are referred to as cribs. A crib is usually made up of pieces of wood of some specific size, stacked in alternating layers to some specified height, representing the fuel load in a given environment. Figure 1-3 provides a depiction of cribs in a 3-D Model.

The fire growth equation to calculate the rate of heat release for the crib for some specified length of time (growth stage). Then approximately the same level of heat release is maintained for another length of time (steady state). Finally, we calculate decay over yet another length of time (decay stage). These three time intervals are given as parameters, and are specific to the crib. Figure 1-4 provides an illustration of the explanation.

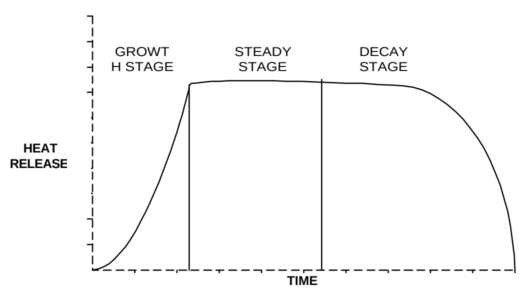

Figure 1-4. Fire Stages

The model involves a three-dimensional grid of cribs. The thermal properties of these cribs are adjusted to account for the type of fuel loading typically found in an aircraft (for example; fuel, tires, and aircraft seats). The model, based on heat release, predict the radiant ignition of surrounding cribs.

Each time a crib is ignited, it begins its own fire growth calculation. To start a fire is simply begin fire growth calculation for some crib.

As the particular crib grows in intensity, the heat release will increase. Likewise, as water is applied to the crib, the heat will decrease. When the heat decreases and

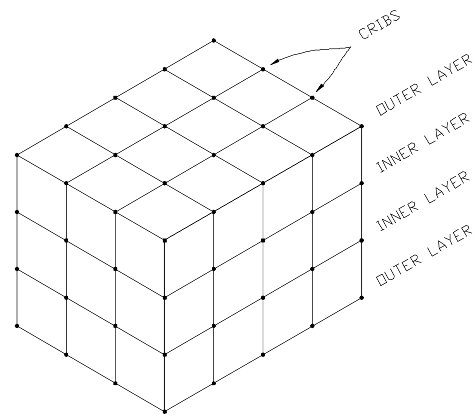

Figure 1-3. Cribs in a 3-D Model

reaches zero, depending on what stage the fire crib is in, the fire will start growing again (growth phase), remain the same (steady state) or decay (decay state). This mechanism gives a simple way to generalize the composite fire behavior from a set of small, discrete fires. Figure 1-5 presents an illustration of the three phases of the fire with the agent applied.

Each object has one or more child objects made up of cribs. For example, the aircraft is broken down into multiple three dimensional cribs such as fuselage, wing landing gear, tires, and engine.

The fuselage is further broken down into multiple three dimensional cribs of seats, fuel tanks, etc. The people objects, vehicle objects, building objects, etc., will also have cribs associated with them. This allows the fire to spread to people, vehicles, buildings, etc. For example, if the people are in the fuselage of the aircraft when the cribs of the interior are on fire, the fire could spread to the people cribs, resulting in the people burning. Dousing the fire with an agent is just a matter of lowering the heat release in each crib reached by the agent. Each agent has a douse value based on the type of fire.

Based on the Incident Commander's performance and his ability to correctly position his equipment, loss of lives can be minimized. Failure to evaluate the aircraft quickly (spending time on jammed doors vs. cutting into the fuselage) could result in more lives lost.

AIRCRAFT/VEHICLE DAMAGE

The initial damage is defined at the start of the exercise. As the exercise progresses, the fire model is simulated by modeling the aircraft or vehicle using cribs. The area surrounding the aircraft or the vehicle (air) is also modeled using cribs, along with fuel tanks, people, weapons, fire-fighting equipment, and other major objects. When a crib of a weapon or fuel tank reaches the explosion point (heat release), an explosion can occur. When the area surrounding the aircraft or vehicle reaches the ignition point, the fire can transfer (depending on wind and other conditions) to other cribs. These air cribs are used to simulate fire transfers that can occur from the engine and wing tanks to the fuselage, under the proper conditions. The aircraft skins are also simulated by using cribs. The utilization of cribs to simulate the tanks, interior of the aircraft, skins, and area around the aircraft/vehicles allows for a realistic simulation of an aircraft or vehicle fire. The behavior of the fire will depend on the fire-fighting procedures, wind conditions, damage (tank leaks), and other important factors of this type.

FUEL TANKS/LINES

The fuel tanks and lines are simulated using cribs. This crib is a three-dimensional model of the fuel load of the area. The outer layer of a tank (skin) has the thermal properties of the skin material, and the inner layer of the tank has the thermal properties of the fuel. The ignition of a crib is based on the heat release of the surrounding cribs reaching the radiant ignition point.

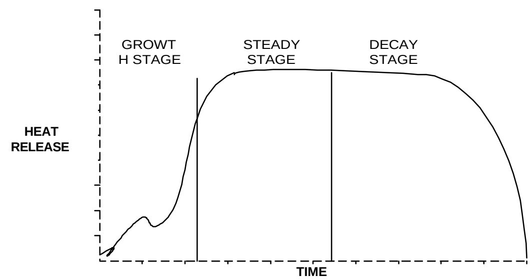

Figure 1-5. Fire Stages with Agent Applied

FIRE PROGRESS

The fire model is realistically simulated using a T-squared crib model. The fire growth equation is used to calculate the rate of heat release for the crib for some specified length of time (growth stage). Then approximately the same level of heat release for another length of time is maintained (steady state). Finally, decay over yet another length of time is calculated (decay state). The volume, intensity, spread rate, direction, temperature, smoke emission, color, and sound of the fire is simulated as a function of the number of cribs on fire, wind, and agents.

FIRE FACTORS

The following factors are modeled into cribs and fire models:

- Exposed surface area of fuel and other combustible: This is modeled using the outer layer of the cribs.

- Combustion Type: This is modeled by setting fuel load and thermal properties of each crib.
- Wind speed and direction: The wind speed and direction alters the radiant ignition of the surrounding cribs.
- Agent type, method, and area of application and rate: This is modeled in the agent objects by reducing the heat release of each crib reached by the agent. Each agent has a different effect on reducing the heat release factor and the area affected by the heat release factor.
- Air supply for internal fires: This is simulated by variables in each crib that indicate air supply available. As the fire spreads, air supply is available or not, depending on the agents applied and available air routes.

COMBUSTIBLE

As a minimum the following fuel load combustibles are required to be simulated in the cribs:

- Fuel
- Rubber
- Magnesium alloy
- Copper cabling
- Interior furnishings-one type

MAGNESIUM ALLOY

Fire properties of magnesium alloy are essential for an effective simulation of aircraft incident. The higher radiant ignition of magnesium alloy require the heat release of the surrounding cribs to be higher. The appropriate length of time for the combustion of magnesium alloy is also important to be included in the simulation.

FLAME COLOR

The fire color is based on the fuel load. The visual cue of varying color to produce a realistic visual simulation of the fire is important. The size of each crib color is dependent on the stage of the fire. Fire represented in colors such as orange/red, blue/green, or white provides the necessary cues.

SMOKE COLOR

The smoke plays a significant role in constructing an effective and realistic representation of reality. The visual system should mix the different crib smokes to produce a realistic smoke simulation. The amount of smoke produced and its color should be dependent on the stage of the fire and, of course, the wind direction.

AGENT APPLICATION

The heat release of each crib, the radiant ignition, and the air supply is dependent upon the application of the various smoke agents. If the agents are applied correctly, the air supply will not be available and will prevent unignited fuel cribs from igniting. Also, if the agents are not applied in the proper amounts to reduce the heat release to zero, re-ignition will occur.

CREW MOVEMENT

The crew moving the turret and sidelines are modeled using a neural network approach. The crew objects are programmed to move the turrets and sidelines in an arc around the area that contains the greatest heat release.

CENTER OF FIRE

The models, unless redirected or stopped by the student, exhibit the greatest heat release at the center of the fire. The agent models will move in an arc around the center point and will apply agents on the nearest fire mass until all cribs' heat releases are zero, unless redirected or stopped by the student. The center of the nearest fire mass is defined as the crib with the greatest heat release within the area reached by the arc of the applied agent.

MINOR FIRES

Simulation of minor fires is an important consideration to make the simulation more realistic. One aspect allows the minor fires to remain only if the agents applied have reduced all fire cribs' heat releases to zero. However, any exercise can start small fires. There can be residual minor fires remaining after the main fire has been brought under control. The use of secondary agents and the deployment of aspirated foam hand-lines are all under the control of the student.

MALFUNCTIONS

Making a simulator an effective training system is a challenge. Not all simulators are alike. A training system that is realistic as well provides meaningful training requires features that are human-engineered for ease of operation. These features provide the user the control over things that can fail in real life. A simulator that is a good training tool allows the operator the ability to set these parameters on demand and vary the complexity of the exercise from basic to a more advanced level. As an example such parameters may include the following malfunctions:

- Break down of appliance
- Appliance air-lock
- Pump failure
- Sideline failure
- Loss of crew member
- Failure of radio communications
- Misinterpretation of crew member instruction

The condition for a malfunction activation is based on either the exercise time or the performance or non-performance of an action by the student.

Armed with the recognition of what was needed to generate the appropriate clues and cues, and with the technical know-how of modeling and simulation to effect training, technology has bridged the gap and now provides a realistic, stressful trainer, which is currently in use at RAF Manston in the United Kingdom.

This cutting edge training system provides incident commanders with a training tool commensurate in complexity and value to the tremendous responsibility faced by these personnel each day. It is a

Illustration 1-2 Virtual Reality Simulation Training Device, Manston AFB, UK

tool that not only measures an incident commander and his crew under stressful and arduous command, control and communications situations, but also allows for the development of the capabilities of our future commanders. By expanding and enhancing their competencies in command and control gradually over time, and monitoring their performance we can allow room for a more effective training program, one that allows to aid them and assist them, not reprimand them. Seeing the mistakes one makes and watching the alternative results that could have been achieved if a different course of action was taken, provide for a very effective training method and allow the incident commander to better deal with a similar situation arising in real life.

The Defence Fire Service in the United Kingdom currently trains in a virtual reality simulation training device that is a real time, interactive, immersive training simulator, providing realistic simulation of serious airport events involving aircraft incidents.

The Civil Aviation Authority commissioned a study to evaluate the Tactical Command Simulator and use of virtual reality simulation techniques for training airport fire officers[4]. The results further emphasized the need for such a system to be integrated into the training programs at airports. The methodology for the evaluation conducted was based on the following elements:

- Realism which it provided
- The ability to develop command and control skills
- Issues relating to pressure and stress
- Relationship to existing training facilities
- Simulator software structures
- Potential benefits
- Other aspects of the simulator

The evaluation was conducted by the University of Teesside in the United Kingdom, who appointed an experienced fire officer to assist with the program. A total of 32 fire service officers from large and small airports were invited to assist with the evaluation process. The observations of the fire officers who participated in the evaluation recorded results where it was clearly evident that within just two or three minutes, the officers became unaware of their natural surroundings and took on the role of the incident commander at the exercise they were witnessing under the virtual reality conditions. Almost all of the officers appeared to be impressed by the high quality of realism of the aircraft and fire situation, which resulted in their becoming quickly immersed in the incident. The availability of technology to deliver such training was no longer in question.

The evaluation clearly indicated that this safe, clean simulation training device, much like those in use today in militaries around the world, is the next generation in preparing our first responders for the responsibilities we have given them in the protection of our airports and the passengers and crews that frequent them. This solution for incident command teams at our airports will meet the needs of complex airport situations well into the 21st century.

Is it not incumbent upon those of us that depend on our valiant and courageous fire service, police and security personnel to provide them with as sophisticated a training device as the sophisticated and complex events they are likely to face at our airports in today's difficult and challenging world? I will leave you with an ancient proverb that states:

Tell Me, and I will forget, Show me, and I may remember, Involve me, and I will learn.

For more information on ETC and our Advanced Disaster Management Simulator (ADMSTM), please visit our web site at www.etcflorida.com, or contact us at (407) 282-3378.

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